

Areas of scientific agreement and disagreement in food and obesity

(a) Mechanisms that link food to obesity by affecting energy balance

Areas of scientific agreement

- Obesity can only develop, as a disease process leading to excess body-fat accumulation and its consequences, if food consumption provides a net excess of calories ('energy') consumed above energy expended, over a prolonged period of time. Many factors influence the amount of body fat accumulation at which energy-balance and weight stability is achieved. These include the food supply and social and cultural influences on food choices and eating, as well as habitual physical activity and activity patterns.
- The pandemic of human obesity (prevalence has increased 5 to 10-fold within 40 years) cannot be explained by global changes in human physiology or genes: conventional genetics research has found only minor effect sizes in common obesity, affecting appetite/food consumption rather than energy expenditure. Major environmental and behavioural changes offer more likely explanations, including increased energy intake in an environment with more available food, and positive influences on food consumption from reduced sleep time, mental stress, and screens/television in addition to inactivity. Occupational physical activity has all but disappeared, and the leisure industry promotes inactivity more than physical activity. Global per capita food supply has risen by ~450 kcal/day, with particular increases in cheaper oils and animal products, SSBs, and larger portion-sizes of foods consumed away from home. Social marketing has normalised new behaviours, such as consuming energy-dense sweet snacks and drinks between meals. Replacing whole-grain and dietary fibre with high GI food products promotes weight gain and metabolic decompensation, especially with insulin resistance and (pre-) diabetes.

Important areas of scientific uncertainty

- The relative importance of changing societal norms for eating and activity, food availability, portion sizes and consumption patterns, to the obesity epidemic remain an understudied area.

It is likely that epigenetic effects from foods and other exposures in early life contribute importantly to the development of obesity, but precise causal pathways, and reversibility, are difficult to establish: the mechanisms may affect regulation of appetite/satiety, or central reward systems and addictive aspects of eating behaviours.

- The human microbiome changes with obesity, and may contribute to metabolic risk, but the extent to which foods or diet patterns may lead to long-term changes in microbiome composition and affect human physiology to promote obesity is still under-researched.

Areas where media opinions and beliefs are commonly not in accordance with evidence

- The role of exercise in weight loss has been persistently inflated. For treatment, RCTs demonstrate only small mean effects of exercise on weight loss, because feasible increases in energy expenditure from exercise are small for most people with obesity. For obesity prevention, exercise is of greater value. It reduces appetite acutely, allowing energy balance at a lower body weight, and there may be an exercise threshold required for achieving energy balance that most persons in post industrial societies do not meet.
- There is very wide confusion between dietary composition for general/cardiovascular health, and for a healthy/normal weight: a health-promoting diet is important for general health but is typically insufficient for weight control when consumed without regard for portion sizes. Conversely, any low energy diet will control body weight if adherence is high, but may not be beneficial for general health. Certain foods and food groups are widely portrayed as having special importance for obesity, either as causes, eg. SSBs, added sugar, refined grains, or as possible protective factors eg dairy foods, yogurt and cheese, nuts, and supposedly 'healthy' fats. The evidence is in keeping with these

foods being useful as markers of diets and lifestyles which promote or protect against obesity, but they do not of themselves have unique properties which affect energy balance.

(b) Diet patterns to support adherence to weight management interventions for weight loss and weight loss maintenance, of current scientific interest

Areas of scientific agreement

- Under metabolic ward conditions, weight change is determined primarily by dietary energy content and energy balance, irrespective of the type or nutritional content of the diet: $EI - EE = \text{change in energy stores}$.
- Under free-living conditions, adherence to dietary recommendations is seldom 100%, and sustaining ongoing weight loss depends on the individual's level of adherence, which in turn can be influenced by diet style and by their preferences and beliefs. Although RCTs and meta-analyses demonstrate minimal or no overall differences between high- and low-carbohydrate/fat diets on long-term effects on body weight, there are clearly individual differences in preference and in carbohydrate-induced satiety, and a range of social, cultural, topical values and beliefs.
- Any diet plan which restricts food choices and opportunities for eating (compared to the previous style of an individual seeking weight loss) will typically generate weight loss in the short-term, eg cabbage soup diet, vegan diet, Atkins diet. Extremely low-carbohydrate diets deplete body glycogen stores and thus reduce body water by about 2kg, which artificially inflates measured weight loss (relative to fat loss) when subjects adhere to the diet in the short term. Well-conducted RCT trials (eg n=1 RCT design) to evaluate the preferences and different responses of individuals in free-living real-life settings have not yet been conducted. At present the weight of evidence favours a moderately low glycemic-load Mediterranean or Nordic diet pattern for achieving better mean results, but some individuals will do better with Japanese or other diets.

Areas of scientific uncertainty

- Research over the last 40 years into cardiovascular and metabolic risks has repeatedly generated conflicting outcomes from higher carbohydrate diets. Effects depend on whether the carbohydrate is predominantly simple sugars, highly-refined starch depleted in dietary fibre and amylose, or if it is from more natural cereal, legume and fruit sources, and on effects from the other non-carbohydrate diet components.
- While evidence is clear that there is no single optimal dietary fat: carbohydrate ratio for weight control, overall, somewhat conflicting evidence suggests that people with prediabetes or metabolic syndrome may be more adherent, and lose more weight, on a lower total carbohydrate or lower glycemic load diet.
- Although individuals with obesity tend to have higher energy expenditure, and metabolic rate falls with food restriction and weight loss, it is not clear whether different time-courses of metabolic adaptation might provide greater energy retention for some people, and whether some dietary patterns may facilitate long-term weight control by reducing metabolic adaptation.
- Various meal patterns of current interest, including time-restricted feeding, and intermittent fasting, may help individuals to adhere to an energy-restricted diet, and they may also have metabolic influence to favour energy balance at a lower body weight.

Areas where media opinions and beliefs are not in accordance with evidence

- It has become fashionable to promote so-called 'palaeo' diets that include large amounts of meat and dairy foods, eliminating grains, beans, soy, some vegetable oils and refined sugar. However, evidence from archaeology, ethnology, biochemistry, physiology and anatomy are not persuasive that this was the usual diet of human ancestors. Humans do not have the specialised carnivore anatomy for a flesh-focused diet, but do possess the high levels of amylase necessary to digest

starchy foods, and require dietary fibre and retrograded starch in order to maintain a healthy microbiome. The well-described primitive hunter-gatherer tribes of South America (eg Tsimane) consume 70% of calories from carbohydrate, much from legumes, are rarely obese and have no heart disease or type 2 diabetes, again suggesting limited justification for palaeo diets, which are also considerably more expensive than nationally-recommended dietary patterns.

(d) Methodology for assessing dietary intake and adherence to a recommended diet

Areas of scientific agreement

- There is no objective way to accurately measure the specific food choices or complete dietary patterns of free-living people. Available methods depend on the subject's memory and honesty in reporting food exposures. All prospective methods are relatively burdensome and introduce behavioural change in food choices. Both intentional and unintentional mis-reporting are common, and people who are overweight systematically under-report food consumption, often to biologically impossible levels.

Areas of scientific uncertainty

- Biomarker methods that assess dietary intake using objective measurements have potential to replace self-assessed dietary intake, at least for some specific nutrients, but the methods are not yet mature and their accuracy and precision are difficult to ascertain.

Areas where media opinions and beliefs are not in accordance with evidence

- It is still commonly reported and assumed that irrespective of physical activity, some overweight people have 'slow metabolism' allowing them to survive on very low energy intakes, and conversely that there are some lucky individuals who can eat any amount of food without gaining weight. While there are some minor differences in energy requirement by body weight, this is generally not true: bigger people need to eat more calories than smaller people, to avoid weight loss.

(e) Long-term behaviour change

Areas of scientific agreement

- Most people do regain some of their intentional weight loss, but not all of it. Both the physiological effects of weight loss, and continuing environmental influences favour weight regain. Individuals who lose weight have reduced energy requirements due to their now-smaller body size, which means that energy intake needs to be lower than in their obese state, to prevent regain. Satiety hormones fall, and orexigenic hormones rise with weight loss, which lead to greater appetite and reduced capacity to resist the promotion of attractive foods. Without ongoing support to resist external cues and encouragement to eat more, the obesogenic environment which led to the obesity is likely to do so again.

Areas of scientific uncertainty

- While a degree of metabolic adaptation during active weight loss is broadly accepted, there is controversy over the persistence of metabolic adaptation after stabilization at the new lower weight and the relative importance of overeating versus metabolic adaptation as causes of weight regain. It is possible but not certain that there are some secondary physiological adaptations to support a lower body-weight after weight loss.

Areas where media opinions and beliefs are not in accordance with evidence

- The widely-held belief that intentional weight loss is futile, because it will inevitably all be regained (especially after rapid weight loss) is not true. There has been minimal investment into scientific research directed at enhancing weight loss maintenance and long-term behavioural changes.

(f) Food craving and eating "addiction"

Areas of scientific agreement

- Central neural mechanisms that determine eating include a reward system that exists to ensure food is consumed as a normal physiological mechanism, without necessarily waiting for hunger. This system is implicated in food cravings and underpins other addictions. The intensity of reward system responsiveness to specific food types differs between individuals and is influenced by factors such as energy density, expected sweetness, and familiarity with packaging or marketing.

Areas of scientific uncertainty

- There is no agreement on the relative importance of different underlying causes (e.g. learned responsiveness, polymorphisms in dopamine receptors) to the different reward system responsiveness of individuals to energy-dense foods.
- The relative importance of food cravings versus other factors in low adherence to interventions for weight loss and weight loss maintenance are also controversial.

The impact of adding caffeine, which is known to be addictive, on consumption of foods and drinks is unclear.

Areas where media opinions and beliefs are not in accordance with evidence

- Widespread assertions that certain foods or nutrients (eg chocolate, sugar) are as addictive as nicotine, cocaine or alcohol are not supported by evidence for addiction. While people find specific foods more desirable, evidence does not support true addictions to specific foods.

(g) Additional future obesity research directions

- The global obesity pandemic is one of the most pressing health challenges of the current era. Obesity-focused research should be to contribute to effective ways to prevent and reverse obesity at the individual level and reduce the prevalence of obesity in populations. This work is needed on a truly global scale, not just in high-income economies, and requires international cooperation to investigate interventions addressing political solutions including fiscal and marketing control . Obesity is increasing everywhere and the negative effects of obesity in one country are exported to others via increased greenhouse gas emissions and reduced national economic productivity.
- In addition to resolving currently topical areas of scientific uncertainty, increased research is needed on neglected, but quantitatively important and potentially malleable behavioural and nutrition factors, such as portion size, eating/snacking frequency and cultural barriers to healthy weight management. Much greater research emphasis is also needed in the relatively underfunded (and therefore understudied) area of sustainable behaviour change for weight management, given the immediate proximity of behaviour change to achieving progress.